An Expert System For Cash Flow Analysis

DANIEL E. O'LEARY, and
W. THOMAS LIN,

One of the most important problems facing management is the management of its cash. Cash flow analysis is a critical part of cash management, concerning itself with budgeting cash flows and diagnosing the causes of positive and negative changes in cash flows. Cash flow analysis is also used to diagnose potential problems and to plan solutions to managing the firm's cash flows.

The purpose of this paper is to discuss a prototype expert system for cash flow analysis. The system, CFA, (CASH FLOW ANALYZER), uses rules based on ratio analysis and a budgetary statement of changes in cash flow in order to budget cash flow, diagnose the source of cash flow problems and to make recommendations.

Recent Developments in Expert Systems

Artificial intelligence can be defined as the study of how to make computers exhibit the characteristics associated with intelligence in human behavior. It includes the simulation of human activities such as robotics, natural language, vision systems, and expert systems.

Expert systems perform tasks normally done by knowledgeable human experts. They are developed by programming the computer to make decisions using the processes and knowledge of the expert.

Expert systems usually have five major components: a knowledge acquisition subsystem, a knowledge base, an inference

engine, an explanation module, and the language interface (Lin, 1986). The knowledge acquisition module requires the accumulation, transfer, and transformation of expertise from the expert to the system. Interactive computer systems use interviewing to obtain this knowledge.

The knowledge base provides the set of knowledge that the system uses to process the data. Typically, this is the domain specific knowledge that the expert would use to solve the problem. Knowledge can be represented a number of ways. One of the most frequently used methods is the rule-based approach. Rule-based knowledge representation generally takes the form of "if . . . (condition) then . . . (consequence/goal)." The rules may or may not include a numerical level of confidence or probability of occurrence.

The inference engine provides the basis for using the knowledge base to process the database. In a rule-based system, the inference engine normally uses either a forward or backward chaining approach. Forward chaining reasons toward a goal. Backward chaining reasons backward from the goal to determine if or how the goal can be accomplished.

The explanation module can explain why the system reached a particular decision or why the system is requesting a particular piece of information. The language interface provides English-like query language or graphics for the user to interact with the expert system.

Applications of Expert Systems in Management Accounting

There have been a number of different prototype expert systems built to solve accounting problems. Recent surveys are given by Akers et al. (1986), Lin (1986), and O'Leary (1986 and 1987).

Other than this paper, there has been at least one other application of expert systems to management accounting problems. Palladium has developed an expert system for use by corporate management in capital budgeting problems (Reitman, 1985). Other possible applications of expert systems in management accounting include transfer pricing, variance analysis, performance analysis, and corporate planning and budgeting.

In addition, the cash management problem is a fertile area for the application of expert systems technology to two other man-

agement accounting tools: linear programming and forecasting. O'Leary (1986) discussed using expert systems in linear programming to help formulate the program and analyze the output by taking advantage of the structure of the problem and the meaning in the variables. Such an approach could be used in cash management. Similarly, an expert system could be used to formulate and interpret the results of forecasts used in cash management. Such a system would take advantage of the domain of cash management to provide meaning to the variables.

Cash Management Models

There have been a number of analytic models developed for the cash management problem. One of the first models proposed for cash management was the EOQ inventory model (e.g., Beehler, 1983). This lead to the application of other inventory models for cash management problems (e.g., Neave, 1969).

Forecasting techniques of varying complexity have been used to estimate cash inflows and outflows. Some of the approaches used included regression analysis and time series.

Unconstrained decision rules based on probability theory also have been developed (e.g., Bierman and McAdams, 1962). Linear programming (Orgler, 1972) and goal programming (O'Leary and O'Leary, 1982) have also been proposed for the cash management problem in order to meet the constraints of cash flow problems.

Unfortunately, analytic models often are not used because users do not understand them or because the assumptions of the model do not fit the situation (Fabozzi, 1976). For these reasons, an expert system designed to interface with the user, using general models that the user understands, e.g., accounting models, may prove to be more useful than some of the analytic models.

An expert system for cash management can be useful to both large and small businesses. Large businesses that have experts specializing in cash management can benefit from an expert system for a number of reasons. First, an expert system would bring to bear a consistent set of knowledge in cash management problems. This could ensure that top management's goals and objectives are considered cash management problems. Second, the system could be used to make recommendations on the

routine decisions, while the expert concentrates on the more unusual problems. Small businesses that may not have the expertise of larger businesses can use the expert system as a source of expertise.

CFA—Cash Flow Analyzer: An Expert System

CFA is a preliminary prototype expert system designed to aid the user in cash flow management. Such an exploratory prototype model is a first step in understanding the development of expert systems for the cash management problem. CFA is a system designed to help the user diagnose cash flow problems, budget cash flows, and plan solutions. The general structure of CFA is given in Exhibit 1.

CFA uses two accounting-based models: ratio analysis and the statement of changes in cash flow. Ratio analysis has been used in at least two previous expert systems. Bouwman (1983) used accounting ratio analysis as the basis of an expert system to diagnose difficulties of firms. Biggs and Selfridge (1986) used accounting ratio analysis as an aid in the development of the "Going Concern" judgment that faces the auditor.

Financial statement analysis provides a number of alternative ratios that can be used in the analysis (e.g., Bernstein, 1978). Ratios can be used to provide insight into the liquidity of the current asset group and the availability of cash. Ratios also can be used to access the cause of cash problems. These ratios can provide information on the source of cash problems and lead to prescriptive recommendations.

The ratios can be compared to benchmarks. If a ratio does not fall within a prespecified range of the benchmarks, then the system can prescribe actions to mitigate the situation. In addition, the trend of ratios can be analyzed to determine if the apparent state of the system is changing and if it is changing, then in what direction the change is occurring. Finally, the ratios can be compared to other ratios to determine the relative strength of the ratio. For example, in cash management, accounts payable turnover is likely to be related to accounts receivable turnover. Thus, relative changes in one ratio can suggest actions in the other.

Both the standards on which the benchmarks are based and the extent and direction of the movement of the ratios should be

GENERAL MODEL OVERVIEW

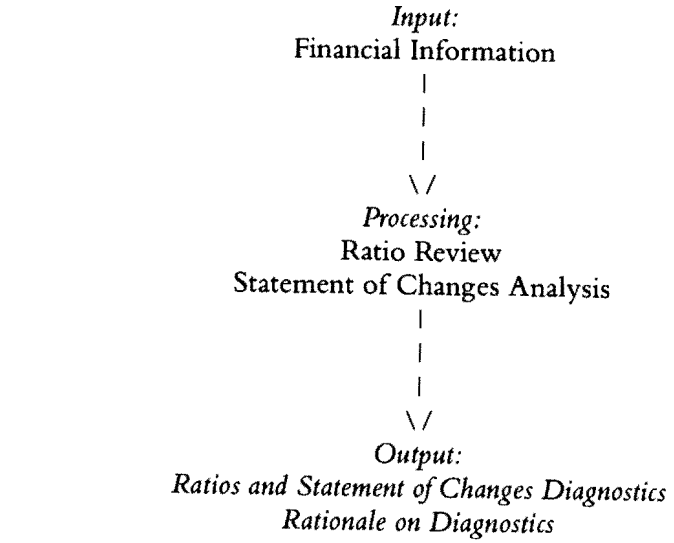

EXHIBIT 1.

developed with the particular firm and industry in mind. In addition, the actions that the ratios suggest should also be developed in concert with the needs of the particular firm. The ratios used in CFA are summarized in Exhibit 2.

The statement of changes in cash flow provides another accounting model that has not been used in the development of previous expert systems, but has been used by accountants to analyze cash flow. The format of this statement can be modified for decision-making purposes. For example, the changes can be grouped by changes in assets, liabilities, stockholders' equity, cash inflows, and discretionary and nondiscretionary cash outflows. Placing the assets in these categories allows the system to make recommendations based on the information that describes that category of outflows. As with the ratios, the actions and the parameters on which the parameters are based are a function of the firm's policies and unique needs. Accordingly, CFA would have to be adapted to the unique situation.

CFA is a rule-based expert system developed using the expert system shell EXSYS. As noted above, there are three types of

LIQUIDITY-BASED RATIOS

Proportion of Cash in Current Assets
(Cash + Cash Equivalents)/Current Assets

Cash Available to Pay Current Obligations
(Cash + Cash Equivalents)/Current Liabilities

Current Ratio

Current Assets/Current Liabilities

Quick Ratio
(Current Assets-Inventory-Prepaid Expenses)/(Current Liabilities)

Accounts Receivable Turnover Ratio
Net Sales on Credit/Average Accounts Receivable

Inventory Turnover Ratio
Cost of Goods Sold/Average Inventory

Accounts Payable Turnover Ratio
Purchases/Accounts Payable

EXHIBIT 2.

rules that use ratio information: comparison of a ratio to a standard, comparison of a ratio to a previous value of the ratio, and comparison of ratios to each other.

A sample rule of the first type would be:

If ((Cash + Cash Equivalents)/Current Assets) is less than cash in current assets-standard, then examine the possibilities to increase cash.

A sample rule of the third type would be:

If accounts payable turnover is less than accounts receivable turnover

Then stretch accounts payables.

The rules that use the statement of changes in cash flow are of a similar nature. For example, the following is a sample rule that compares a quantity to a standard.

If net operating cash flows are less than the net operating cash flow standard

Then make arrangements to borrow.

Summary

This paper discussed an expert system for cash flow analysis based on traditional accounting models of cash flow. The scope of expert systems in cash management can range from the current system to systems that include and explain the output from analytic tools such as linear programming or forecasting tools.

This system and other such cash management systems can aid cash flow analysis in a number of ways. First, they can lead to a consistent analysis of the input data, minimizing the inconsistencies of human information processing. Second, they can analyze the information at the "initial screening level" and let the expert spend his or her time analyzing the more difficult aspects of the problem. Third, such systems allow the transfer of cash management expertise to those firms that do not have such expertise.

References

Akers, M. D., G. L. Porter, E. J. Blocher, and W. G. Mister, "Expert Systems for Management Accountants," *Management Accounting,* March 1986.

Beehler, P. J., *Contemporary Cash Management,* John Wiley & Sons, 1983.

Bernstein, *Financial Statement Analysis,* Irwin, 1978.

Bierman, H. and A. K. McAdams, *Management Decisions for Cash and Marketable Securities,* Graduate School of Business and Public Administration, Cornell University, 1962.

Biggs, S. and M. Selfridge, "GC-X: A Prototype Expert System for the Auditor's Going Concern Judgment," paper presented at the University of Southern California Symposium on Expert Systems, February 1986.

Bouwman, M., "Human Diagnostic Reasoning by Computer: An Illustration From Financial Analysis," *Management Science,* Vol. 29, No. 6, June 1983.

Fabozzi, F. F. and J. Valente, "Mathematical Programming in American Companies: A Sample Survey," *Interfaces,* Vol. 7, 1976, pp. 93–98.

Lin, W. T., "Expert Systems and Management Accounting Research,"

Management Accounting News and Views, Vol. 4, No. 1, Spring 1986, pp. 11–13.

Neave, E. H., "The Stochastic Cash Balance Problem with Fixed Costs for Increases and Decreases," *Management Science,* Vol. 16, 1969.

O'Leary, D., "Expert Systems in Mathematical Programming," in *Military Artificial Intelligence Applications,* Operations Research Society of America Monograph, forthcoming.

———, "The Use of Artificial Intelligence in Accounting," in *Expert Systems for Business,* B. G. Silverman, (ed.), Addison-Wesley, 1987.

——— and J. O'Leary, "A Goal Programming Approach to a Hospital Cash Management Problem," in Proceedings of the Fifteenth Annual Hawaii International Conference on System Sciences, 1982.

Orgler, Y. E., *Cash Management,* Wadsworth, 1972.

Reitman, W., "Application of Artificial Intelligence Technology to Management in the '80s," unpublished paper presented at the Forum on Artificial Intelligence in Management, Richmond, VA, May 1986.